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No. 22,055/35.

APPLICATION DATED

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Applicant (Actual Inventor) .. .. ARNOLD NESBITT MACNICOL.  
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Class 12.3.

Drawing attached.

### COMPLETE SPECIFICATION.

**"Improved method of and apparatus for separating particles of different specific gravities and recovering those desired."**

I, ARNOLD NESBITT MACNICOL, of No. 11 Phillip Street, Sydney, in the State of New South Wales and Commonwealth of Australia, Consulting Engineer, hereby declare the invention and the manner in which it is to be performed, to be fully described and ascertained in and by the following statement:—

This invention relates to the separation of particles of different specific gravities and recovery of those desired, and has been specially devised in order to provide an improved method of and apparatus whereby the desired particles whether the heavier or lighter may be separated and recovered.

The improved method of separating particles of different specific gravities constituting finely ground material and recovering those desired, comprises the centrifugalization of either a continuous or intermittent supply or flow of a mixture of material constituted of finely ground particles and a suitable liquid into a rapidly rotating vessel having a plurality of axially spaced, circumferentially arranged and centripetally disposed riffles which may be in any convenient form such as in the specification of my Australian Letters Patent No. 17,457/34, or

spaced vertical and circumferential intersecting ribs or hands, discharging washing or agitating liquid, generally water; or agitating fluid such as air or carbonic or other suitable gas or gases, radially or at suitable angle or angles in the direction of the wall and riffles thereof, and discharging at regulated pressure washing or agitating liquid, generally water, or agitating fluid, such as air or a suitable gas, from the base or most radial point of each riffle, centripetally, that is against centrifugal action, or at an angle thereto, in order to stir and diffuse the lighter particles so that they will be carried up in the upwardly moving content of the vessel and away in the overflow therefrom, or may be skimmed off or otherwise removed at or near the top.

The specific gravity of certain of the particles may be varied as convenient or suitable by the addition to the mixture of a suitable liquid such as an oil of low specific gravity, or the discharge therein of a suitable gas, or both liquid and gas, having a selective affinity for, or action upon, desired particles.

It will be understood that when the specific gravity of such a particle is altered by the addition of a liquid such as oil of low

specific gravity or a gas such as carbonic acid, or both, which will adhere to, envelop, or combine with the previously heavier valuable particles, the specific gravity of the particle shall be that of the combination, and in this circumstance the originally or naturally heavier particles become the lighter particles and they are carried up to the top of the vessel and skimmed off or obtained from the overflow.

An improved apparatus according to one construction comprises a vessel whose depth or length is preferably greater than its diameter which is adapted to be rapidly rotated at desired speed upon its axis which may be vertical or horizontal, or at any angle therebetween, and, in one construction, has upon or in the inner face of its wall a plurality of axially spaced, circumferentially arranged and centripetally disposed riffles, preferably in the form of centripetally open recesses which may be a circumferentially arranged plurality of independent though adjoining recesses, though each may be annular, and from the deepest or most radial point of independent recesses an orifice, and from an annular recess a plurality of circumferentially spaced orifices, and upon or about the opposite, or more radial face of the vessel, a jacket to form a common passage to all the orifices whereby washing or agitating liquid or agitating fluid may be discharged at regulated pressure either continuously or intermittently to cause disturbance, agitation or diffusion of the lighter particles so that they will be carried up in the upwardly moving content of the vessel and may be skimmed off or otherwise recovered, or will be carried off in the overflow from the vessel, and may be recovered therefrom, the pressure being such that it will be just sufficiently greater than the centrifugal momentum of the lighter particles and less than that of the heavier particles so that the latter will not be prevented from lodging in or upon the riffles or dislodged therefrom, but the former will be, and inside the vessel a mixture supply and discharge pipe or shaft, also a washing or agitating liquid or agitating fluid supply and discharge pipe, or a spaced plurality thereof.

The apparatus may comprise only one vessel, but preferably will comprise a plurality of vessels, either arranged vertically, one above the other, or one within or about the other, upon a common hollow

shaft, each, except the highest or innermost, to receive the overflow from the adjacent vessel, and if desired in the multiple construction the liquid or fluid jacket about each vessel may be omitted.

And in order that the invention and practical applications thereof may be readily understood the same will now be described with reference to the accompanying drawings, in which:

Figure 1 is a sectional elevation of an improved apparatus.

Figure 2 is a fragmentary section of a vessel wall with modified arrangement of inlet openings.

Figure 3 is a sectional elevation of a modified construction of vessel.

Figure 4 is a sectional elevation of a multipole vessel apparatus in a vertical arrangement.

Figure 5 is a fragmentary section of a modified arrangement of the vessels upon a common shaft, and

Figure 6 is a sectional elevation of a multiple vessel apparatus in a horizontal arrangement.

Referring to Figure 1, the vessel 11 which is mounted upon hollow shaft 12, which is in suitable bearings and adapted to be rotated by suitable means, such as pulley 14, and has openings 13 and is plugged therebelow, has riffles 15 formed on or secured to the inner face of its wall, and from the deepest or most radial point between each pair of riffles 15, orifices 16, which may be replaced by narrow circumferentially arranged through slits or slots, has discharge openings 17 in the base 18, and has thereabout a supply and pressure jacket 19, enlarged at the top to form a trough 20 which has cleaning plugs 21 therein, and the bottom is in communication by pipes 22 and connection 23 to the lower part of the hollow shaft 12. Supported beneath the base of the vessel is a receiving trough 24 with discharge direction spout 25. Inside the vessel is a washing or agitating liquid supply pipe 26, or spaced plurality thereof, having discharge openings 27 directed radially at suitable angle.

The orifices 16 may be those in a woven or perforated screen or sheet 28 held in position upon the inner face of the vessel wall over larger orifices or slots 29 therethrough by rings 30 pressed into position, and which may serve as riffles.

In a modified construction of the vessel as in Figure 3, it may have the rifles 15 vertically disposed, and be provided with a vertically adjustable separate top rim or ring 31 in order to vary the escape space between said rim and the vessel wall, a convenient manner of supporting the rim and effecting adjustment thereof in relation to the vessel top being a plurality of brackets 10 32 upon the vessel and an operable threaded stem 33 through each bracket 32.

This construction and arrangement of vessel is suitable for operation when the heavier particles are to have their specific gravities reduced by the adhesion thereto, envelopment thereof, or the combining therewith of suitable buoyant material or substance which has a selective affinity for, or action upon, desired particles which is added to or introduced into the mixture, either before it is fed into the vessel, or while therein, the adjustment of the top rim 31 by manipulation of stems 33 controlling the exit and overflow of the floating foam or froth bearing the particles which have been carried up thereby or therein.

Referring to Figure 4, a plurality of vessels 11 which may have rifles 15 formed as shown, or otherwise desired, or as in Figure 1, are mounted vertically spaced upon a common hollow shaft 12 which is in suitable bearings, is adapted to be rotated, such as through gear 34, has an opening 35, or a plurality thereof, to each vessel, and a slidable hollow valve rod 36 with openings 37 through its wall to juxtapose with the opening 35 or plurality thereof, so that either, or all of the vessels may be opened, when desired, to the hollow shaft 12, which in this arrangement is used as a discharge pipe.

Inside each vessel is a mixture supply pipe 38 which may be a branch from a main mixture supply pipe 39, also a washing or agitating liquid or fluid supply pipe 26 which also may be a branch from a main pipe 40.

The vessels may be constructed as shown in Figure 4 or with the addition of the jacket 19 thereabout, and a supply pipe 41 up through the hollow shaft 12, and there may be a splash case 42 about the apparatus with a declined bottom to a spout 43.

In this arrangement, overflow from a higher vessel will pass into the one thereunder, and that from the lowest into the case 42.

So that one or some of the vessels 11 upon the common shaft 12 may remain stationary while another or others are rotated thereby, they may be arranged as in Figure 5, each vessel 11 being free to rotate upon the shaft 12, and supported by a friction block 44 fast upon said shaft, and means are provided for raising each vessel independently from its block 44, such means conveniently being a lever 45 which is fulcrummed upon a suitable support such as a bracket upon the splash case 42 or a bar 46 conveniently anchored, and has on one end forks 47, each carrying a roller 48, and its other end connected to an operable rod 49 or telescopically arranged tubes 50.

When it be desired to stop rotation of a vessel the requisite lever 45 is operated to raise the vessel from its supporting friction block 44.

Referring to Figure 6, a plurality of vessels 11, which may be constructed in any of the manners before described, but requisitely of varying diameters, may be formed integral, that is with a common base 18 through which from each vessel are the discharge openings 17 into respective troughs 51, 53 and 55 which are connected by pipes 52, 54 and 56 to the hollow shaft 12 at different positions, and in which is the slidable hollow valve rod 36.

Inside the innermost vessel is the mixture supply pipe 38, and inside each vessel is a washing or agitating liquid or fluid supply pipe 26, or plurality thereof, and inside each vessel other than the innermost is a mixture overflow guide plate 57 which is at an angle reverse to that of the vessel's outer wall, and may be conveniently supported from the shaft 12 as shown.

If it be desired that the vessels be provided with external jacket 19, same may be added as shown, and be connected by a pipe 58 up through the hollow shaft 12.

As a convenience there may be provided a fixed gauge 59 secured to any convenient support, and a pointer 60 on the sliding valve rod 36.

The valve rod 36 may be removed from the hollow shaft 12 while the vessels are working, to avoid wear, but must be replaced before the speed of the vessels is reduced low enough to allow the content to flow out of the vessels before desired.

A high pressure jet of water may be forced down the centre of the hollow shaft 12 to assist in the removal of the material.

In one operation (Figure 1) the vessel 11 being rotated at requisite speed, the mixture is supplied thereto either continuously or intermittently through hollow shaft 12 and its openings 13 at desired pressure, and discharges in the direction of the wall of the vessel and/or the riffles thereof, washing or agitating liquid is discharged either continuously or intermittently at desired pressure from the pipe or pipes 26 into and through the mixture, and a further or counter discharge of the liquid or other liquid or fluid which is supplied through the lower portion of the shaft 12, and by the pipes 22 to the jacket 19 is effected either continuously or intermittently through the orifices 16 at the deepest point between the riffles 15, the object being to attain disturbance, agitation and diffusion of the lighter particles so that they will be carried up to top of content of, or off in the overflow from, the vessel.

At termination of operation, the vessel is flushed or washed out by requisite application of water to dislodge the heavier particles which are between the riffles 15, and will be washed down into the trough 24 and discharged through spout 25 to where required.

If desired the heavier particles may be allowed to pass through the vessel into the jacket 19 and be recovered therefrom such as by opening the lower end of the hollow shaft 12 and flushing through the plug-holes 21, or by opening those holes and flushing through the shaft 12 and pipes 22.

With a vessel constructed and arranged as in Figure 3 with a hollow shaft 12 or a mixture supply pipe 38, and washing or agitating medium supply pipes 26 therein, a substance and/or material which has a selective affinity for, or action upon, and will adhere to, envelop, or combine with, the desired heavier particles and render them lighter than the others is added or introduced to the mixture, through the pipes 26 if desired, and rotation of the vessel causes a separation and/or diffusion of the particles, and those which have been rendered lighter are carried in the resultant froth or foam to the top and are either skimmed off or are allowed to overflow through the space between the vessel rim and the adjustable ton ring 31.

The operation with an apparatus as shown in Figure 4 and in Figure 6, is much the same as described with reference to

Figure 1 though repetitional according to the number of vessels provided, mixture being supplied through pipe 38 to each vessel, as in Figure 4, in addition to that overflowing from a higher into a lower vessel, but to only the innermost vessel when they are arranged as in Figure 6, and the overflow from that vessel will have to pass down between the wall and the plate 57 to escape into the next vessel, and so on.

Having now fully described and ascertained my said invention and the manner in which it is to be performed, I declare that what I claim is:—

1. Improved method of separating particles of different specific gravities and recovering those desired, consisting in the centrifugalization of a mixture of such particles and liquid discharged into a requisitely rotated vessel towards the wall which is adapted to receive and retain the heavier particles, discharging washing or agitating liquid or agitating fluid into the mixture in said vessel in the direction of the wall of said vessel, and discharging washing or agitating liquid or agitating fluid through the wall of said vessel in centripetal direction, to cause agitation in the content and separation and/or diffusion of the lighter particles so that said particles will be carried off in the overflow from said vessel.

2. Improved method of separating particles of different specific gravities and recovering those desired as in Claim 1, in which the wall of the vessel has centripetally disposed or open riffles and washing or agitating liquid or agitating fluid is discharged through orifices in said wall at or about the deepest or most radial point between or in the riffles of said wall.

3. Improved method of separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to Figure 1 of the drawings.

4. Improved method of separating particles of different specific gravities and recovering the desired heavier valuable particles consisting in the centrifugalization in a suitable vessel of a mixture of particles and suitable liquid to which is added or introduced a substance or material which will adhere to, envelop or combine with the heavier valuable particles to render them of less specific gravity than

the other previously lighter particles, so that they will pass to the top of the vessel to be recovered.

5 5. Improved method of separating particles of different specific gravities and recovering the desired heavier valuable particles as in Claim 4 hereof, in which a washing or agitating liquid or agitating fluid is discharged into the mixture during the  
10 centrifugalization.

6. Improved method of separating particles of different specific gravities and recovering the desired heavier valuable particles substantially as described and explained with reference to Figure 3 of the  
15 drawings.

7. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising a rotatable vessel having riffles upon or in the inner  
20 face of its wall, openings through the wall between the riffles or thereinto, means for supplying liquid or fluid to the outer end of said openings, and inside the vessel a mixture supply pipe and a washing or agitating liquid or fluid supply pipe or plurality thereof respectively adapted to discharge  
25 mixture and washing or agitating liquid or agitating fluid at desired angle or angles towards the wall of the vessel.  
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8. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising a rotatable vessel having riffles upon the inner  
35 face of its wall, a top ring vertically adjustable in relation to the rim of the vessel, and means for effecting the adjustment of said ring.

9. Improved apparatus for separating  
40 particles of different specific gravities and recovering those desired, comprising a vertically spaced plurality of vessels upon a common rotatable vertically disposed shaft, and means for supplying mixture to the uppermost or each vessel and means for discharging washing or agitating liquid or agitating fluid in each said vessel.  
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10. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising the combination with one or more of the vessels as in Claim 9, of means for discharging liquid or fluid through its wall between or into the riffles on the inner face thereof in  
55 a direction against, or at an angle to, centrifugal action.

11. Improved apparatus for separating particles of different specific gravities and recovering those desired as in Claims 9 or 10 in which the vessels are disengageable from the rotating shaft so that one or some  
5 may remain stationary while the others are rotated with said shaft.

12. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising a horizontally arranged plurality of vessels upon a common vertically disposed rotatable shaft, and means for supplying mixture to the innermost or each of the vessels and means for discharging washing or agitating  
15 liquid or agitating fluid in each said vessel.

13. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising the combination with each of the vessels other  
20 than the outermost as in Claim 12, of means for directing the overflow to near the bottom of the next outer vessel.

14. Improved apparatus for separating particles of different specific gravities and recovering those desired, comprising the combination with one or more of the vessels as in Claim 12, of means for discharging liquid or fluid through its wall between or into the riffles in a direction against, or at  
30 an angle to, centrifugal action.

15. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to  
35 Figure 1 of the drawings.

16. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to  
40 Figures 1 and 2 of the drawings.

17. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to  
45 Figure 3 of the drawings.

18. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to  
50 Figure 4 of the drawings without means for discharging liquid or fluid through the walls of the vessels.

19. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to  
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Figure 4 of the drawings with means for discharging liquid or fluid through the walls of the vessels.

20. Improved apparatus for separating 5 particles of different specific gravities and recovering those desired substantially as described and explained with reference to Figures 4 and 5 of the drawings.

21. Improved apparatus for separating 10 particles of different specific gravities and recovering those desired substantially as described and explained with reference to Figure 6 of the drawings without means for discharging liquid or fluid through the walls 15 of the vessels.

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22. Improved apparatus for separating particles of different specific gravities and recovering those desired substantially as described and explained with reference to Figure 6 of the drawings with means for 5 discharging liquid or fluid through the walls of the vessels.

Dated this thirty-first day of January, A.D. 1936.

ARNOLD NESBITT MACNICOL. 10

By his Patent Attorney,

PERCY NEWELL.

Witness—Mary A. Fox.

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